Bicyclist Crossing Times: Implications for Bicyclist Signal Timing

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Outline

- Issues to consider in bicyclist signal timing
- Measurements of crossing times
  - Experimental method
  - Experimental results
  - Interpretation of results
- Simulations of effects on traffic
  - Simulation method
  - Simulation results
- Recommendations for signal timing

Issues to Consider

- **Current bicyclist crossing times**
  - **Emphasis on standing starts**
  - **Consider delay time from signal change**
  - **Diversity of bicycling population across locations**
  - **What percentile of crossing behavior to accommodate?**
- **Impacts on mainline traffic of longer green crossing intervals to accommodate bicyclists**
  - **Possible increased delays and queue lengths**
  - **Differences between peak and off-peak traffic conditions**
  - **Interference with mainline signal coordination**
  - **Compare with effects of pedestrian cycles**

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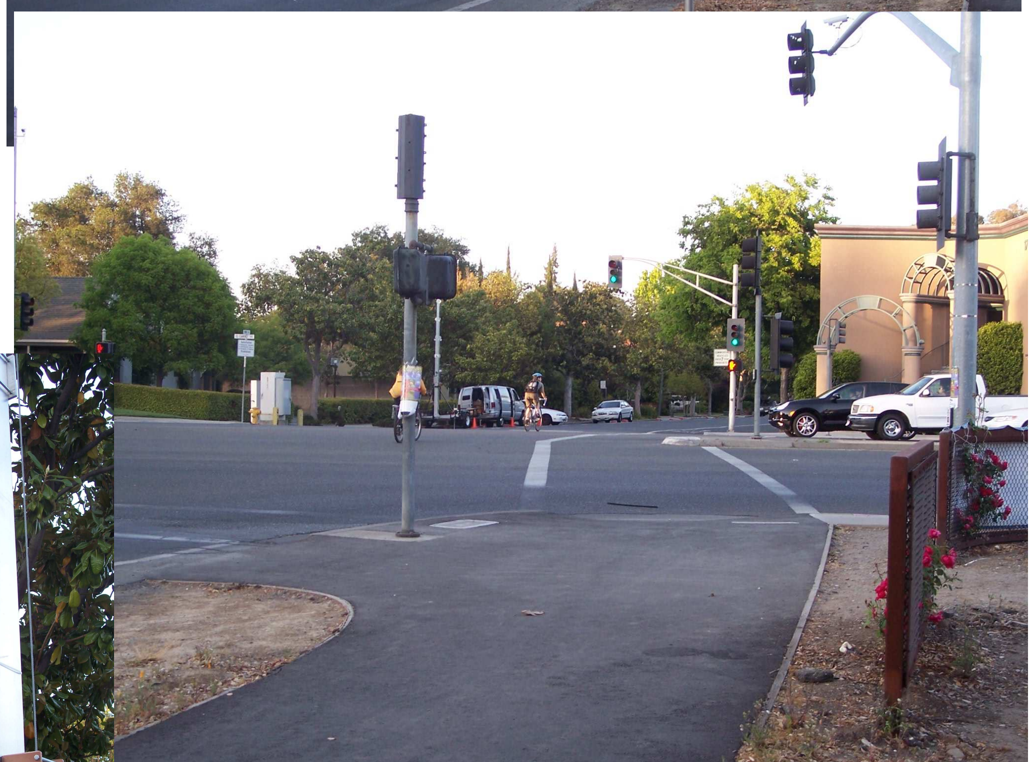
Crossing Time Measurement Method

- **Digital video recording at busy bicyclist crossing locations**
  - **Video image processing software tracking bicyclist motion**
  - **Analyst tags start and end of crossing while watching playback**
- **Traffic signal status recording and synchronization with bicyclist motion data**
  - **Direct communication from signal controller (data losses and timing problems)**
  - **Separate video camera watching signal head, post-processed with image processing**

Observation Sites

- **Two intersections along El Camino Real (SR-82) in Palo Alto, recommended for high bicyclist traffic by City of Palo Alto**
  - **California Ave. (northeast bound) – commuter traffic returning from Stanford Industrial Park**
    - **Observation from an unoccupied office site**
  - **Park Blvd. (northeast bound) – commuter traffic returning from Stanford University campus**
    - **Roadside observation from trailer**
- **Telegraph Ave. at Russell St. in Berkeley (Bike Boulevard crossing)**
  - **Observed both direction of travel**
  - **Diverse bicycling population and timing**

Video Observation Equipment at Park Blvd.

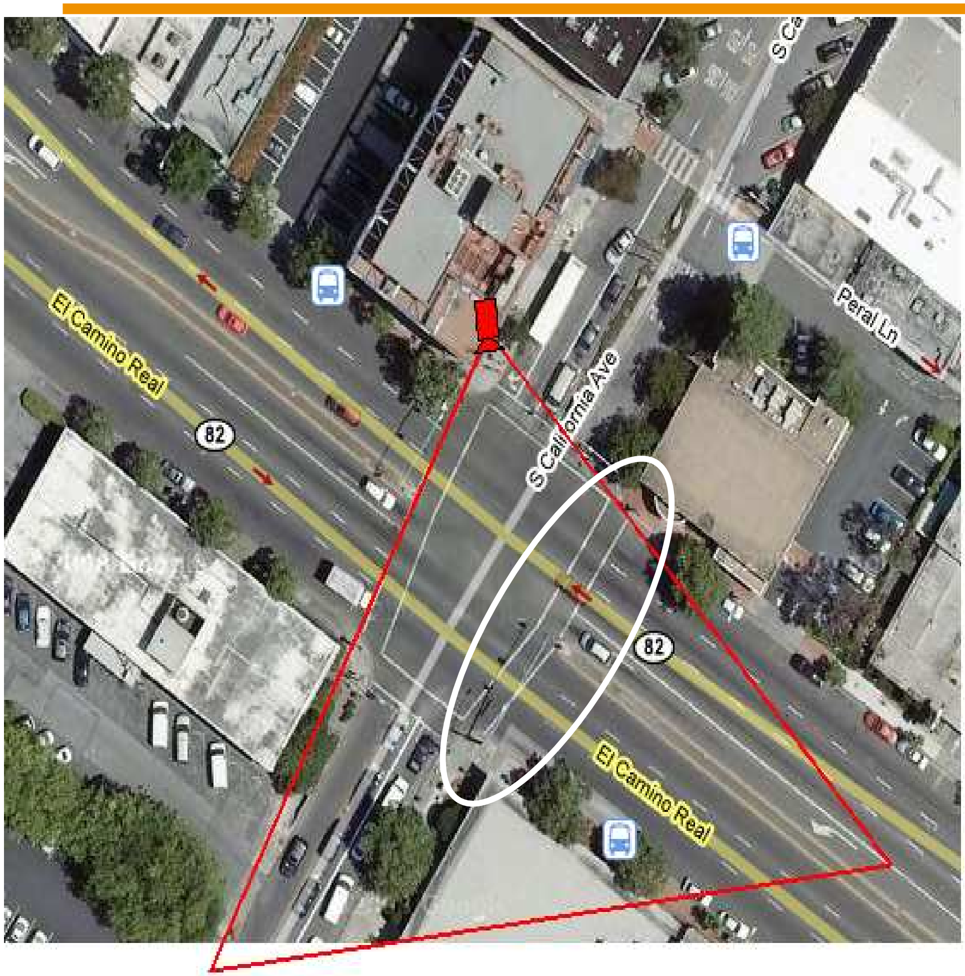


Video Observation Equipment at Russell St

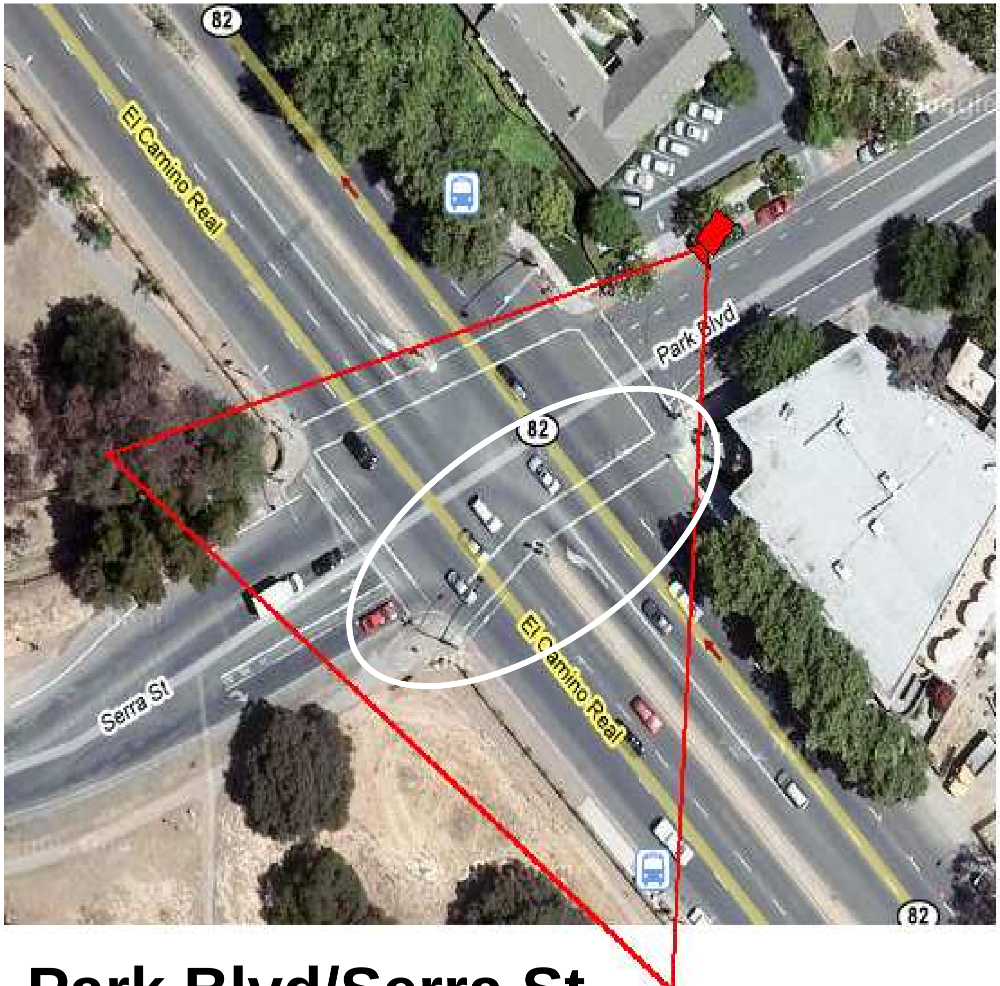
Facing Westbound

Facing Eastbound

Google Earth Views of Both Palo Alto Sites

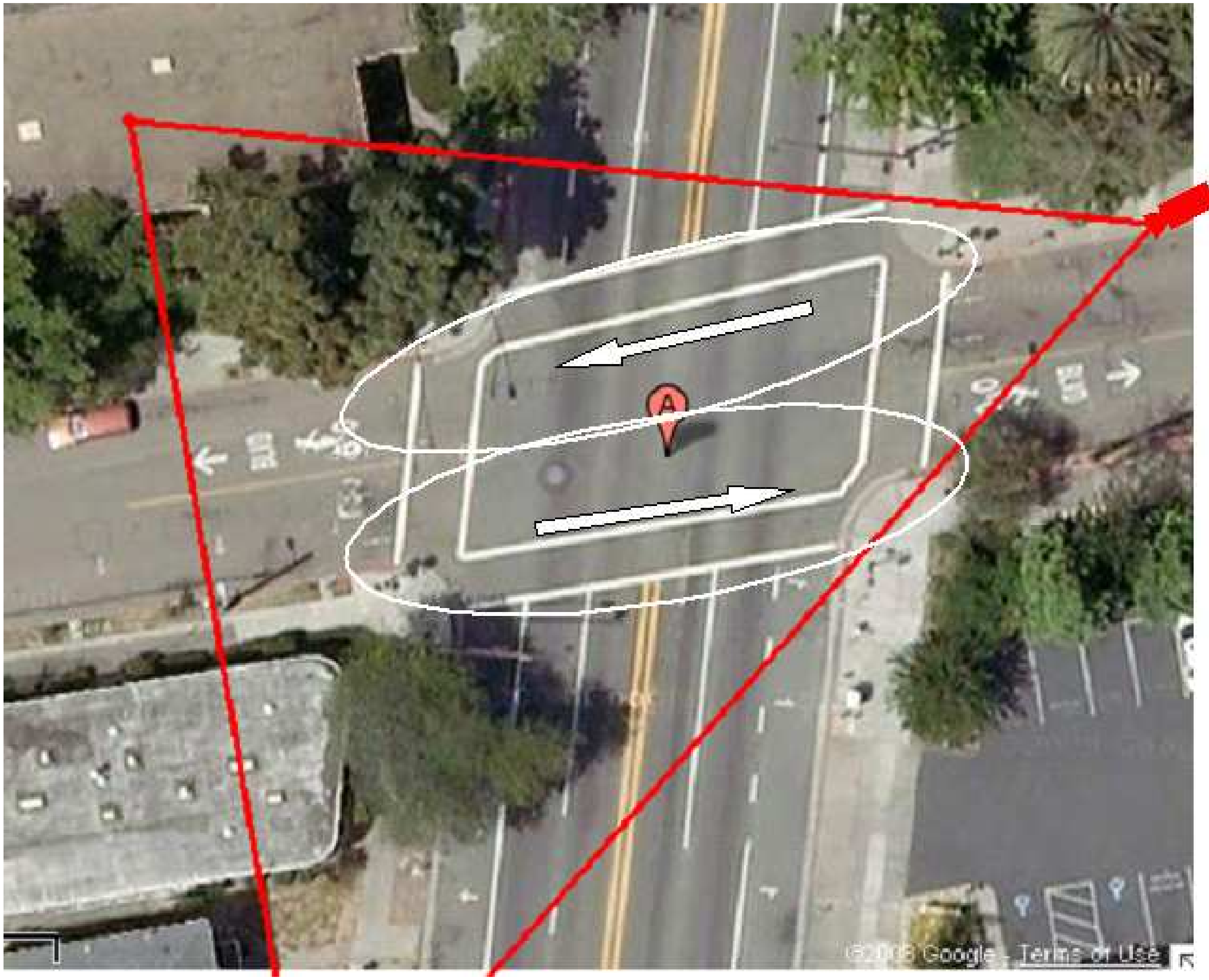


California Ave.



Park Blvd/Serra St

Google Earth View of Berkeley Site



Video Data Imagery (Examples)

Quantity of Usable Data – Daylight Only

- **Park Blvd. (2 days)**
  - 320 total bicyclist crossings (265 usable)
  - 188 standing starts
  - 77 rolling starts
  - Includes traffic signal timing data
- **Russell St. (3 days)**
  - 439 usable bicyclist crossings
  - 279 standing starts
  - 160 rolling starts
  - Both directions of travel
  - Includes traffic signal timing data

Contrasts Between the Two Sites

	Palo Alto	Berkeley
Width	125 ft, 7 lanes	84 ft, 4 lanes
Speed Limit	40 mph	25 mph
Traffic	Heavy	Moderate
Intersection	Crowned	Flat
Visibility	Limited	Better
Approach grades	Flat	-3.4%, +2.5%
Bike traffic	Evening commute	All day
Bicyclists	Young adults	Diverse

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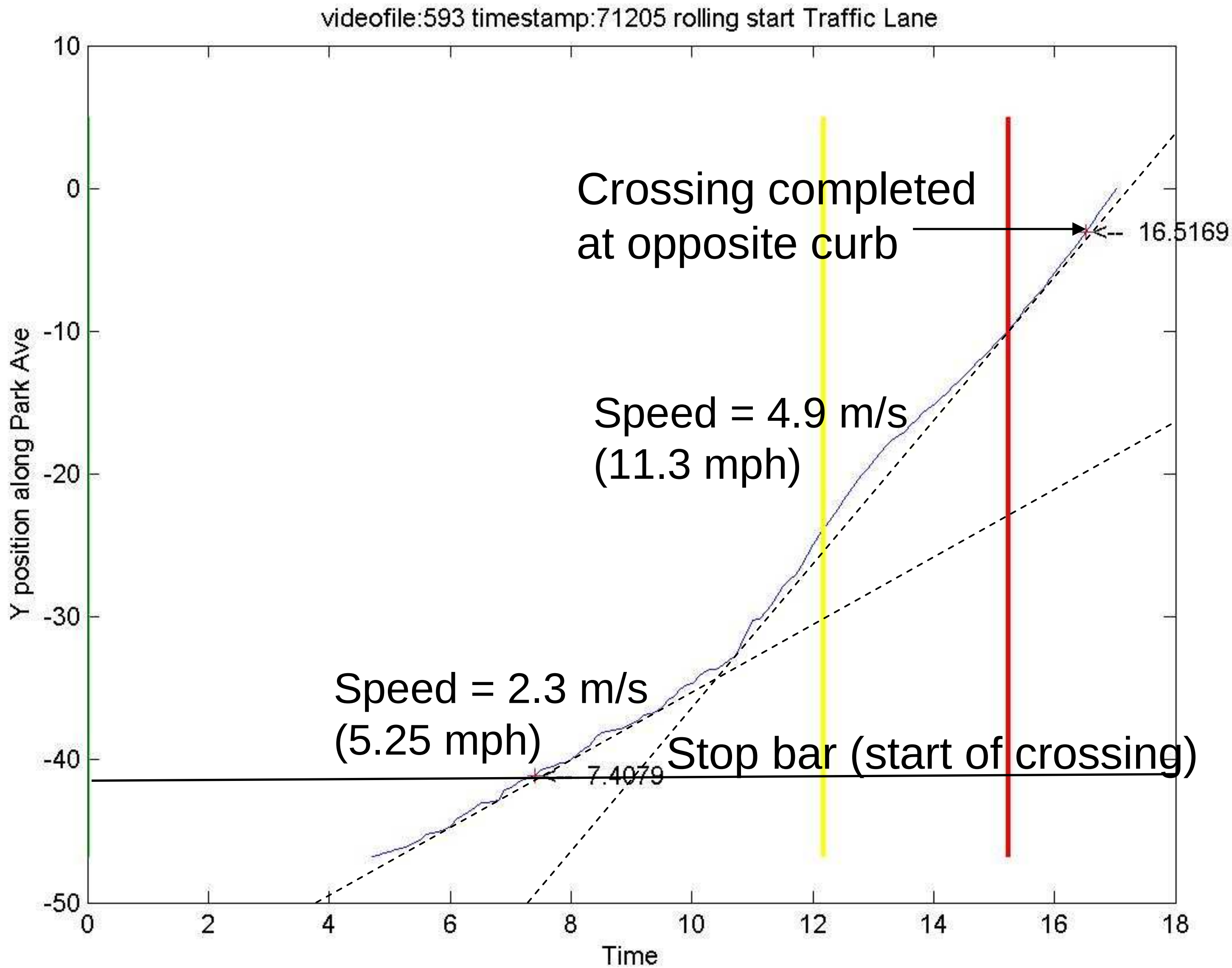
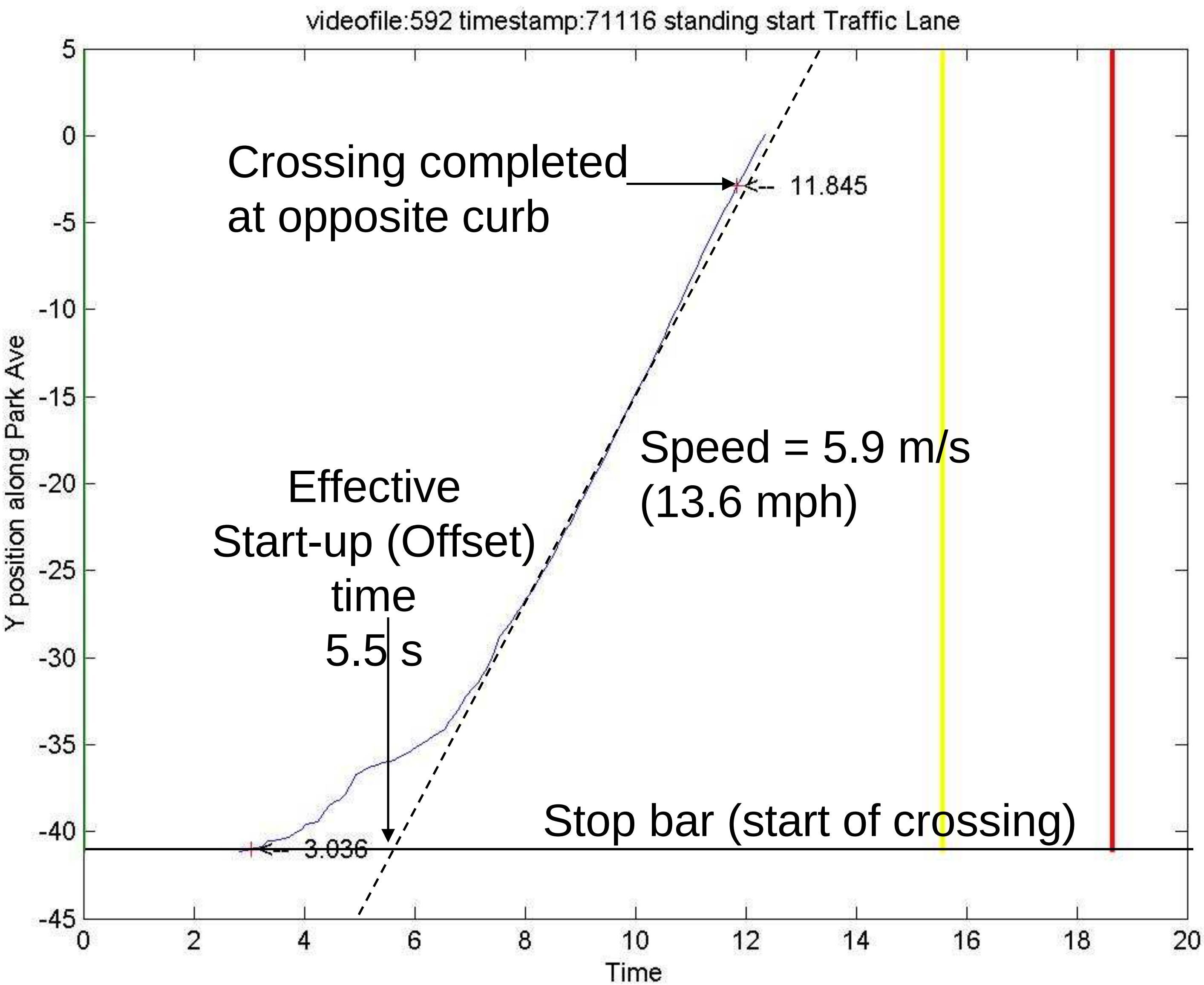
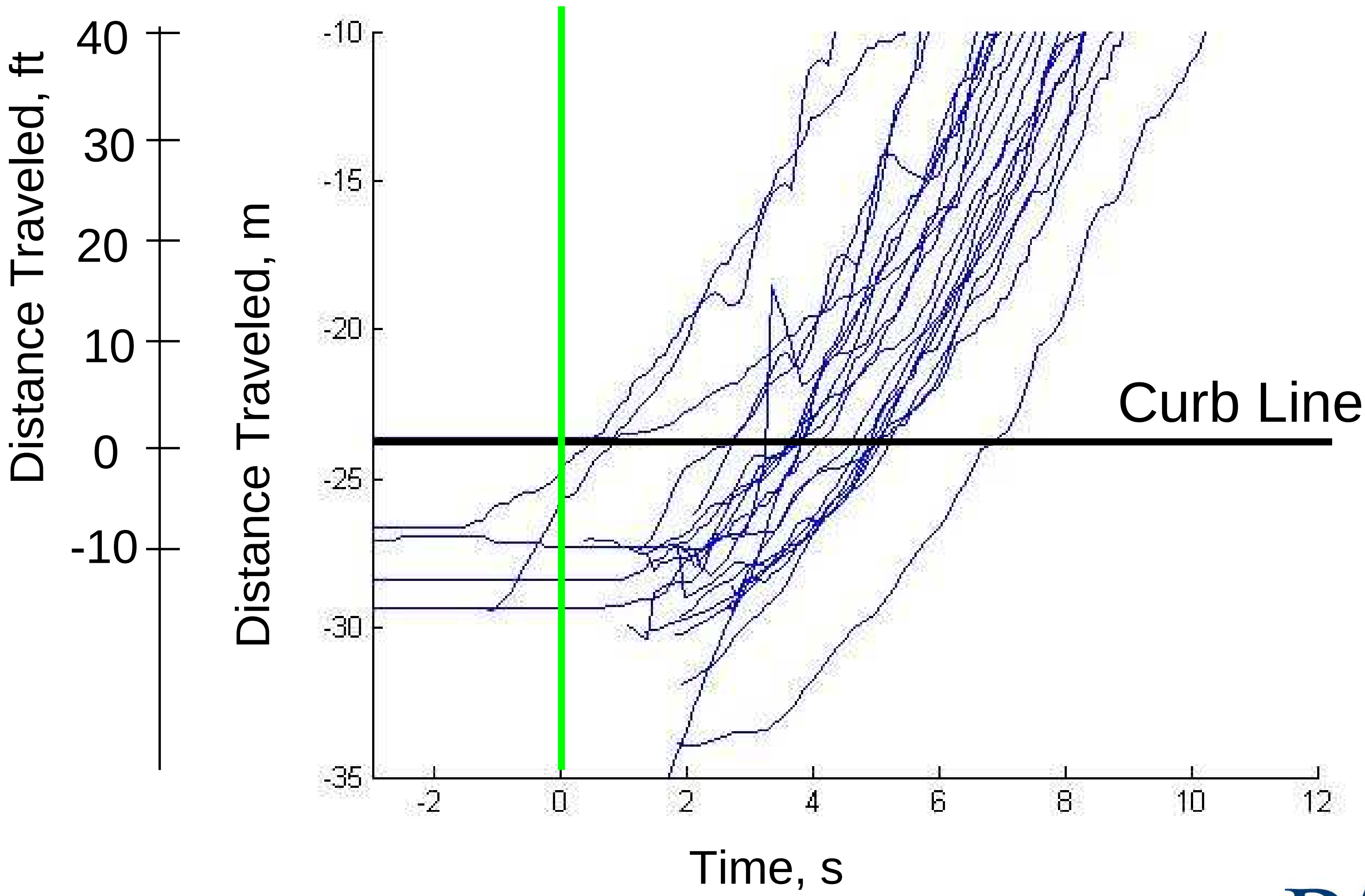
Example Rolling Start, With Speed Change



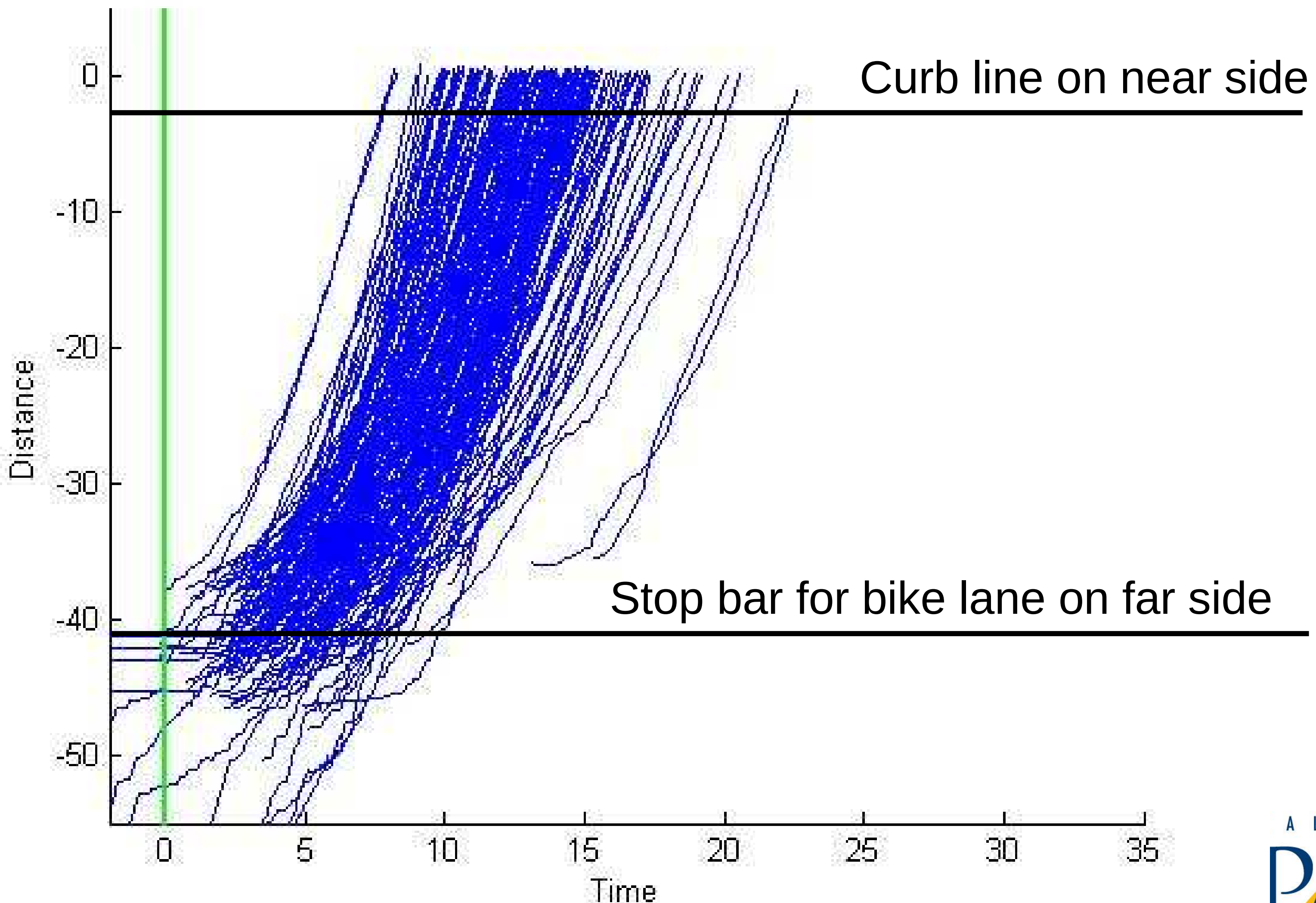
Example Standing Start Estimates from Data



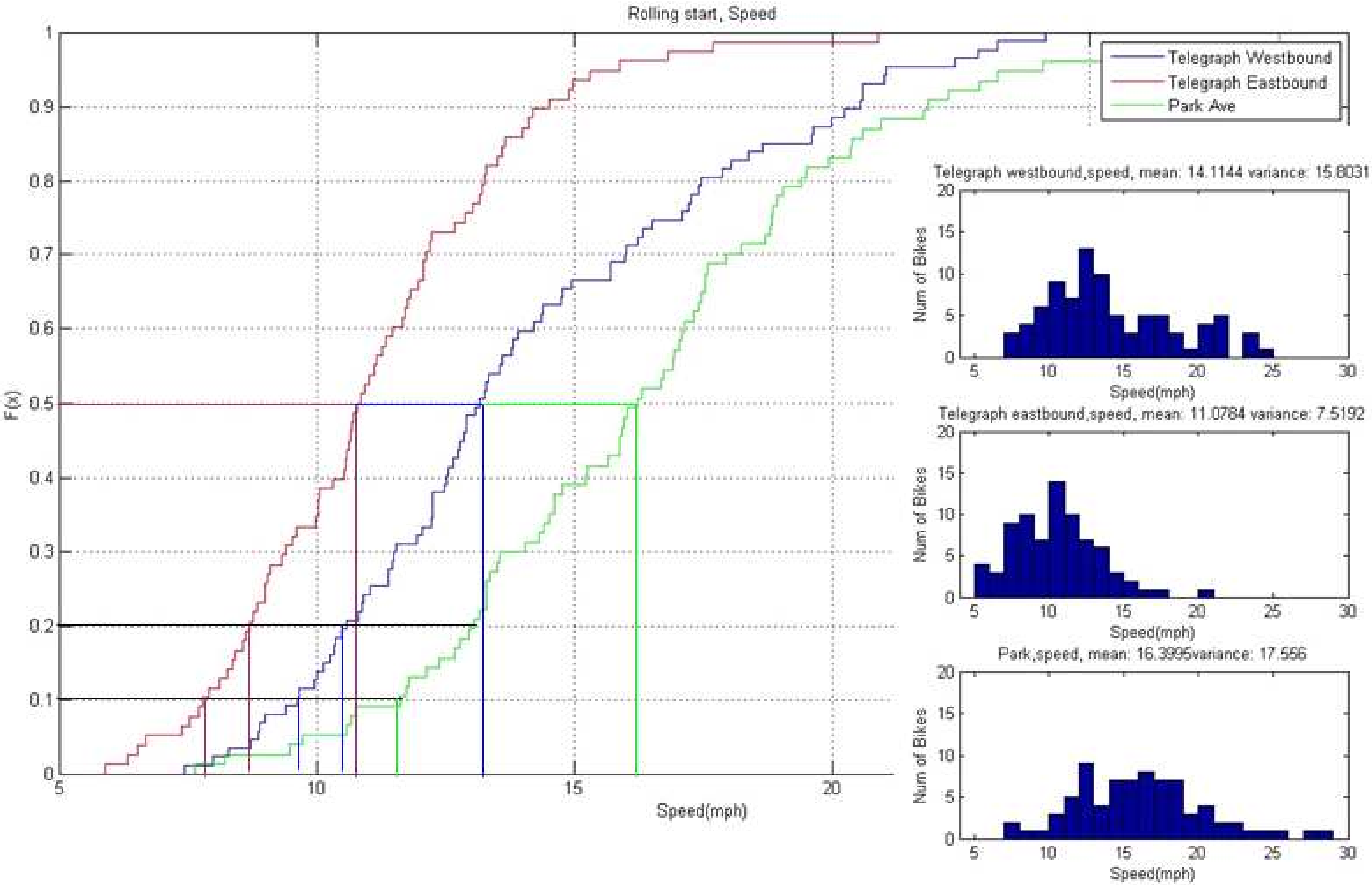
Close-Up of Some Standing Starts (Southwest-bound Bike Lane at Park)



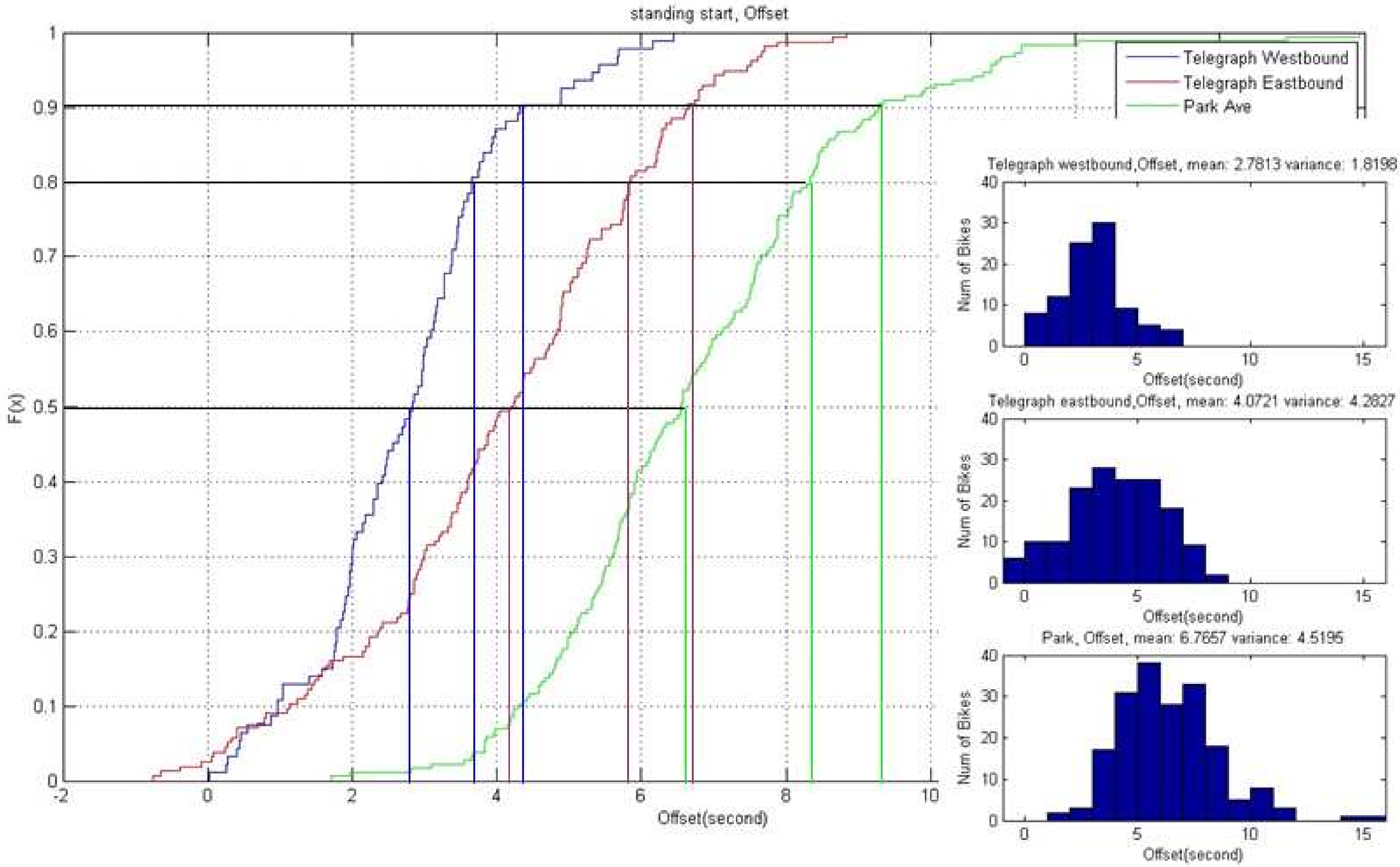
All Standing Starts at Park



Distribution of Final Speeds (mph) for Rolling Starts



Start-Up Offset Times (Relative to Green Onset) for Standing Starts



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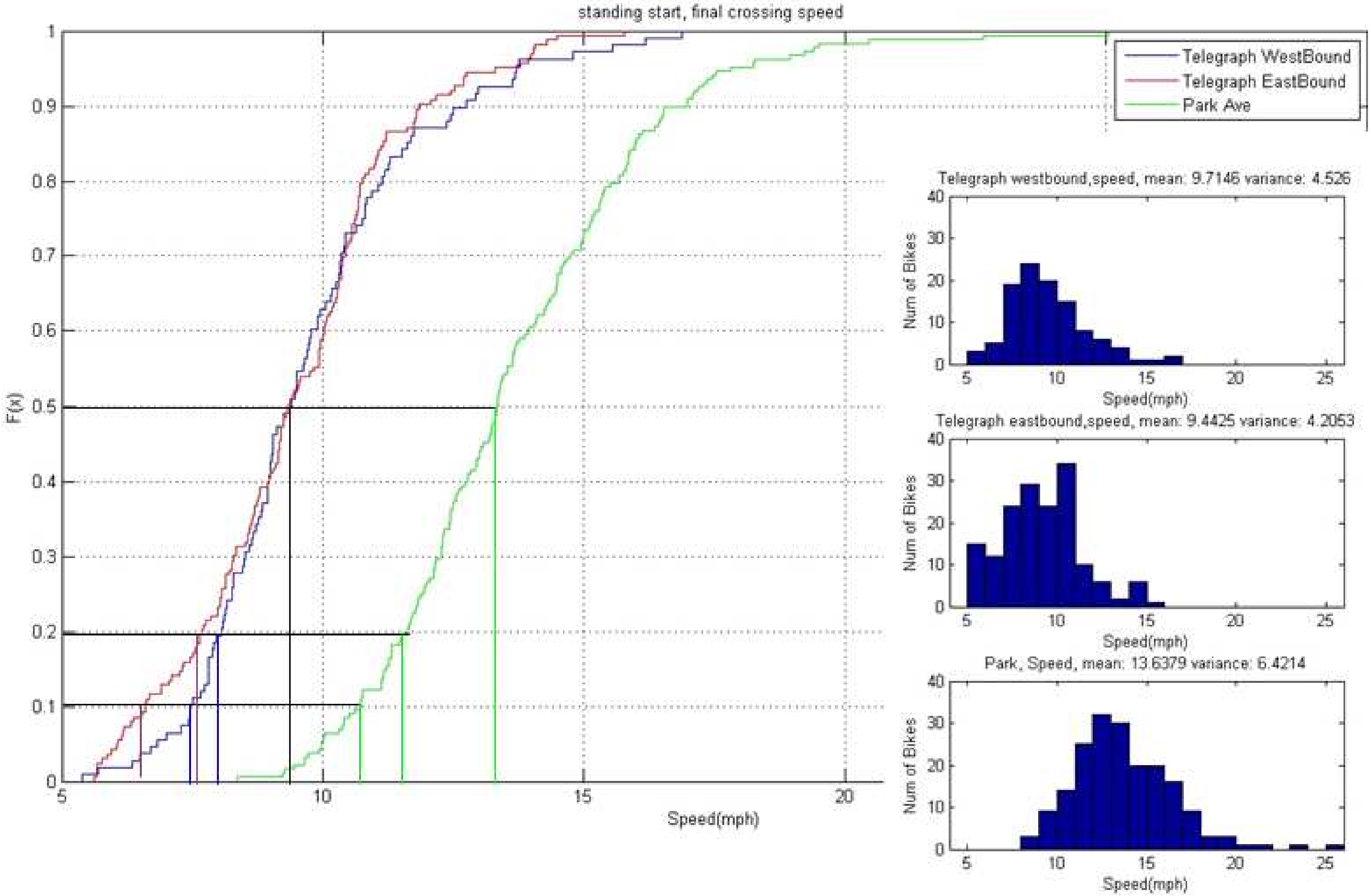
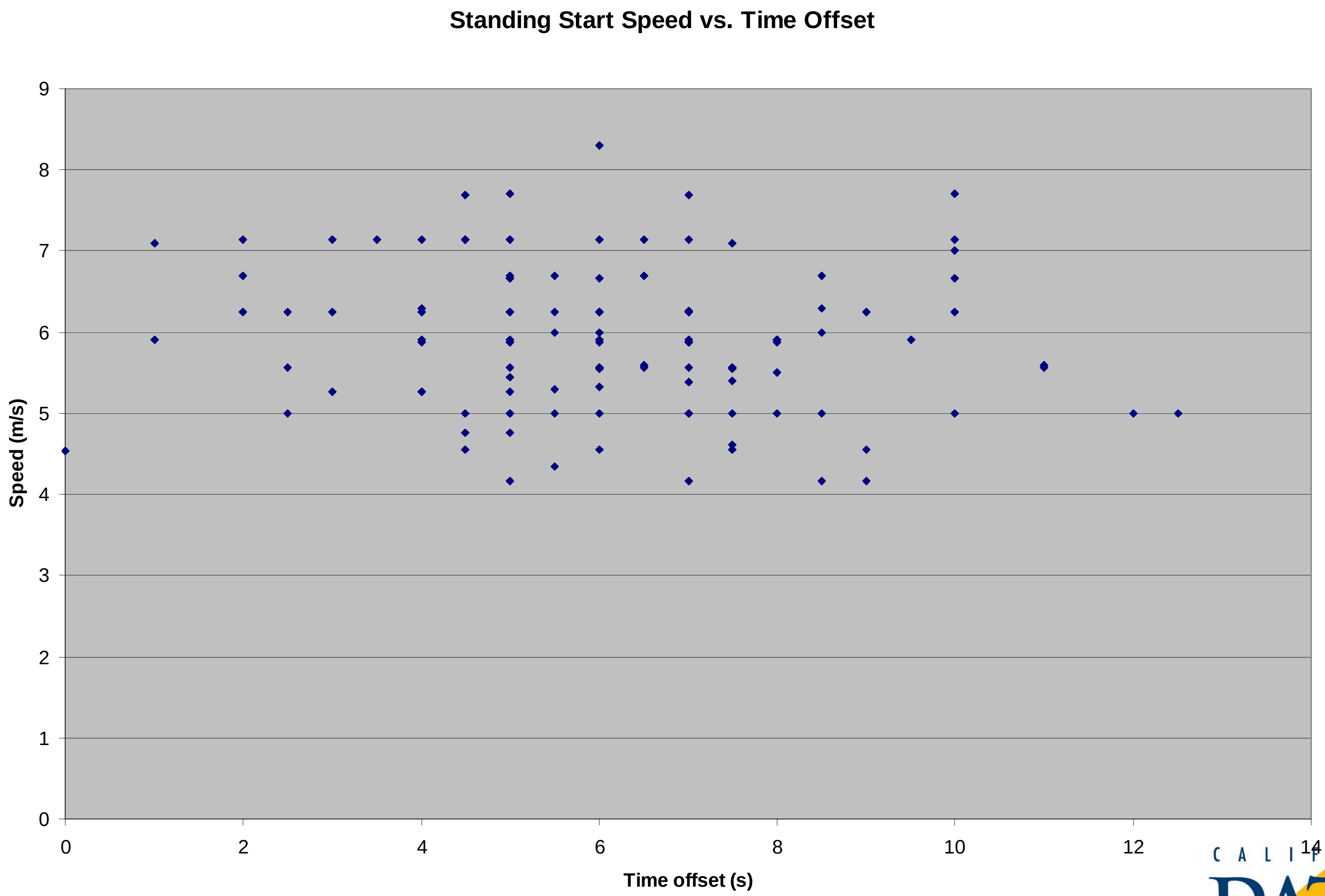
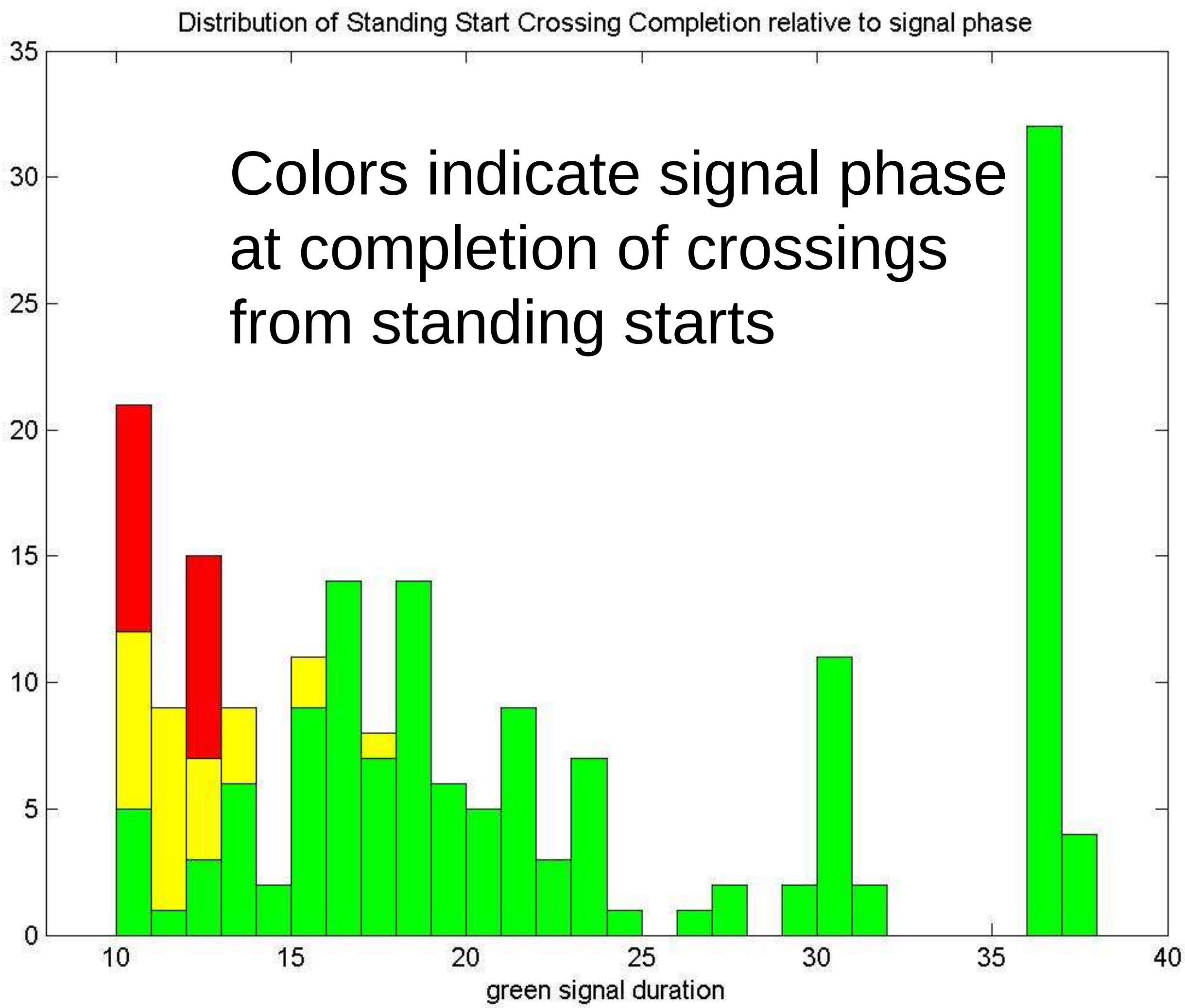


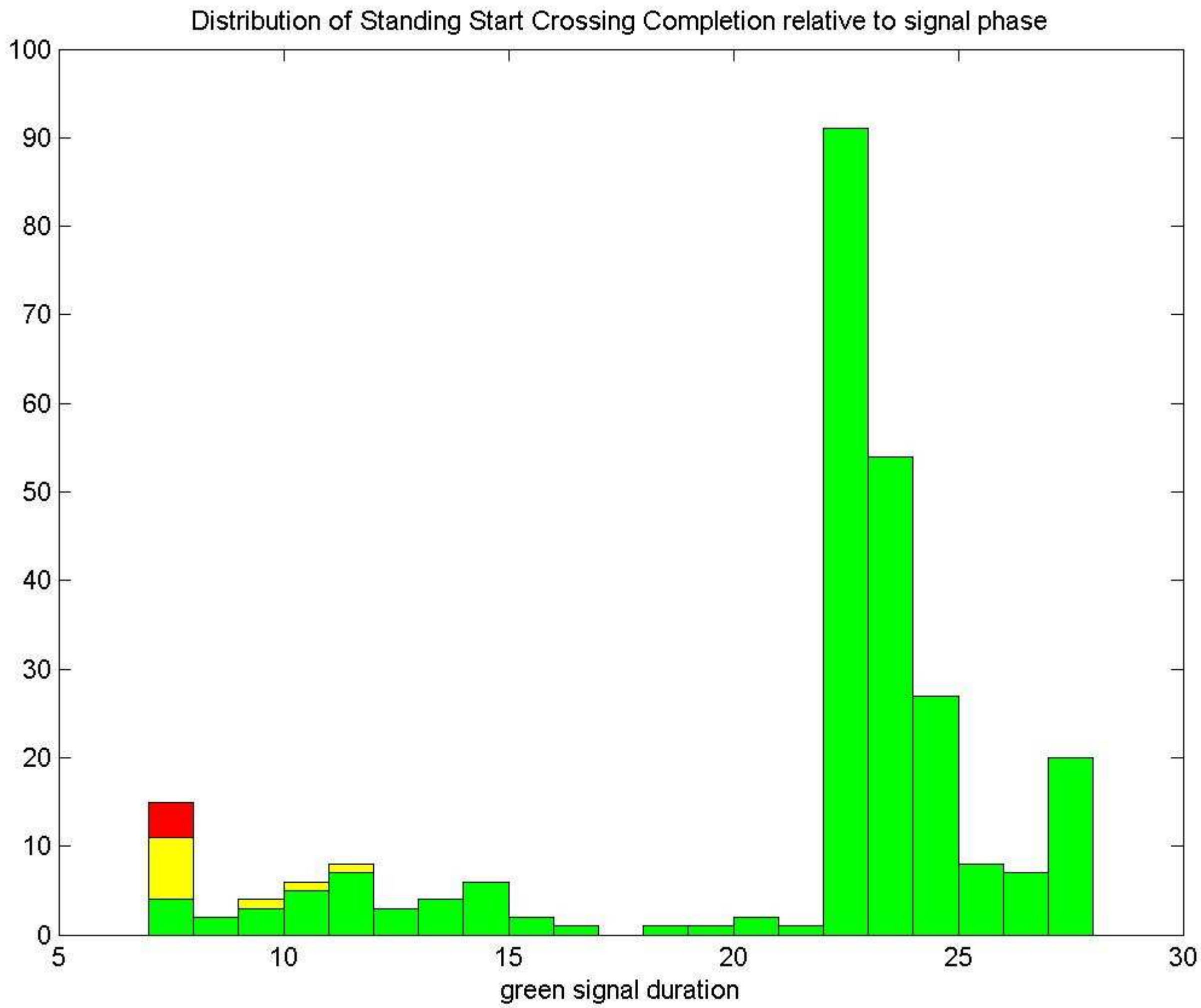
Independence of Final Crossing Speeds and Start-Up Times at Park



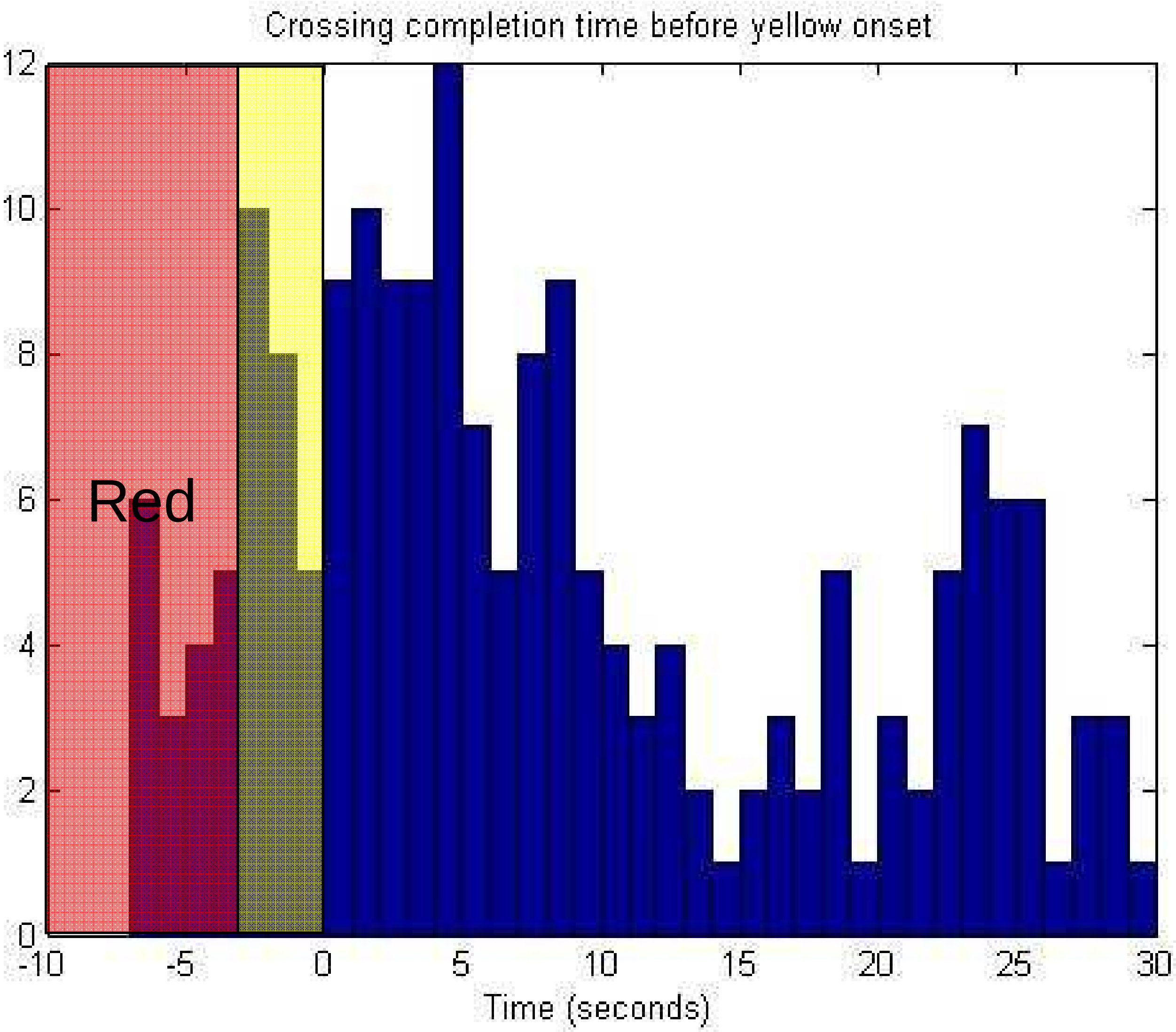
Duration of Green Time When Bicyclists Were Crossing at Park



Duration of Green Time When Bicyclists Were Crossing at Russell



Standing-Start Bicyclist Crossing Completion Relative to End of Green at Park



Summary of Candidate Timing Criteria for Standing Starts

%ile accommodated	Start-Up Offset Time	Continuous Speed Assumed
90% Palo Alto *90% Berkeley*	9.3 s *6.2 s*	10.5 mph *7 mph*
80% Palo Alto *80% Berkeley*	8.3 s *5.3 s*	11.5 mph *8 mph*
50% Palo Alto 50% Berkeley	6.5 s *3.5 s*	13.3 mph *9.4 mph*

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Key Findings on Bicyclist Crossing Behavior

- Substantial diversity in speeds and start-up times at each site, but they're not correlated in Palo Alto
- Palo Alto start-up offset times ~3 s longer than Berkeley average
  – More dangerous cross traffic
  – Need to climb crown on El Camino
  – Differences between directions in Berkeley
- Palo Alto final speeds ~4 mph faster than Berkeley
  – Young adult commuters
  – Descending crown on El Camino

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Simulation of Effects on Traffic

- **VISSIM micro-simulation of El Camino Real corridor from Churchill (Palo Alto) to Grant (Mountain View) – 6 miles**
- **Afternoon peak traffic loading**
- **Current (2005) Caltrans signal timing**
  - **Actuated, but coordinated along El Camino**
  - **Minimum green intervals of 7 sec. at most cross-streets in Palo Alto (11 sec. at school access streets)**

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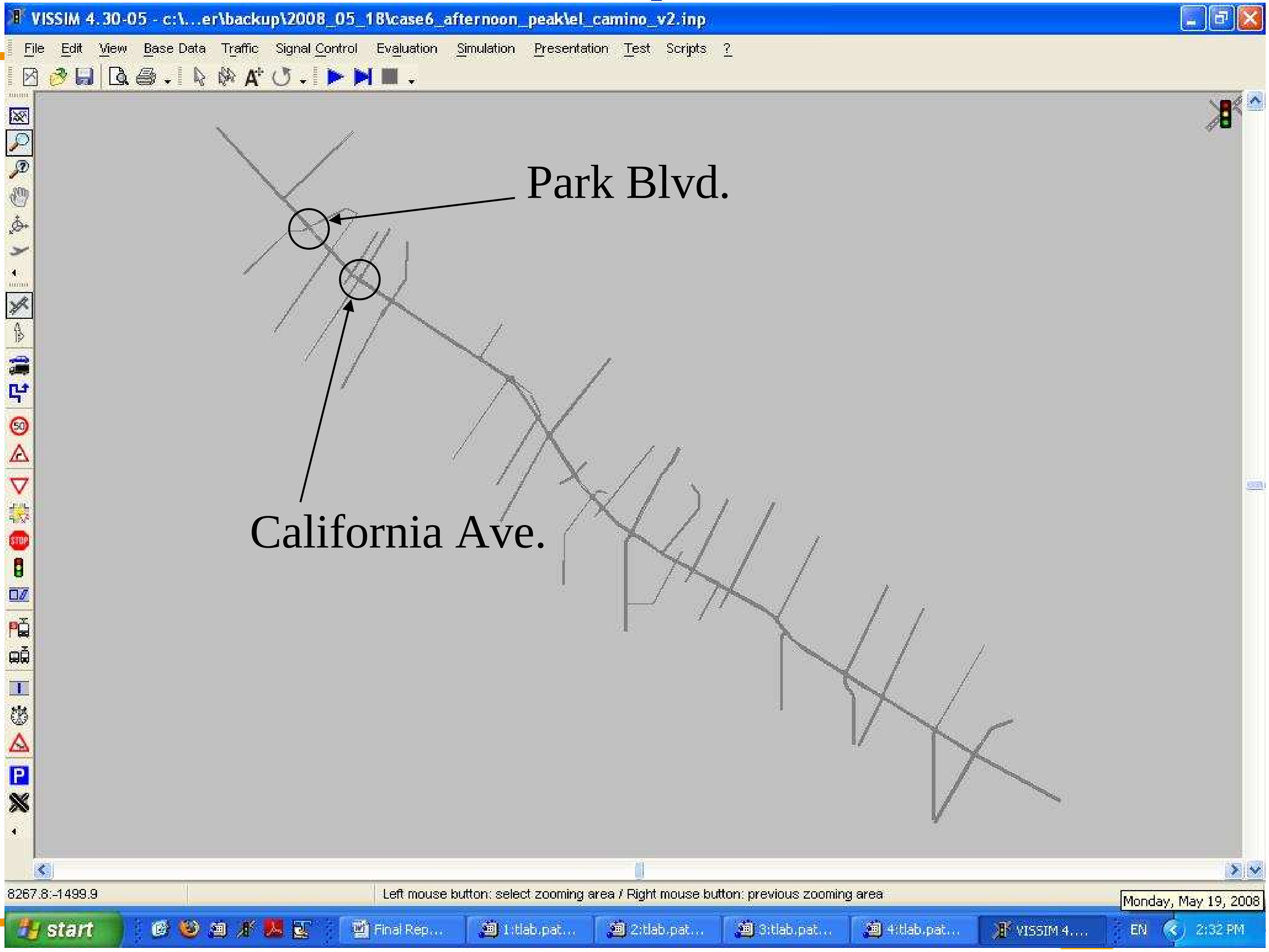
VISSIM Network Representation



Simulation Cases

1. Current baseline conditions
2. Increase minimum green at California from 7 s to 9 s
3. Increase minimum green at California from 7 s to 11 s
4. Increase all cross-street minimum green times by 2 s
5. Increase all cross-street minimum green times by 4 s
6. Add ~20 pedestrian cycles per hour at California (based on observed data during busy periods, with heavy bike traffic)

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Simulated Average Traffic Delays

- VISSIM provides average for entire corridor
- Additional 2 or 4 seconds of minimum green at California increased network average delay by only ~0.5 sec (~0.6%)
- Additional 2 or 4 seconds of minimum green throughout the corridor had barely measurable effect (+/- 0.17 sec)

→ Differences small enough to be marginal

→ During busy period, vehicles on California were already holding green beyond minimum

Simulated Queue Lengths at California

- For the simulated condition, only southbound El Camino had any significant queuing at California (averaging 47 ft. in base case)
- Changes in queue length:
  - + 2.2% for 2 sec. minimum green at California
  - + 4.4% for 4 sec. minimum green at California
  - + 3.5% for 2 sec. minimum green throughout corridor
  - + 9.2% for 4 sec. minimum green throughout corridor

→ Worst of these cases (+9.2%) only represents additional ¼ car length

Simulated Effects of Pedestrian Cycles

- **Pedestrian signal cycles were simulated at the rate observed during PM peak while collecting bicyclist crossing data (20 pedestrian cycles/hr)**
- **Effects on traffic were much larger than effects of increasing minimum green by 4 s:**
  - **Increased southbound El Camino queue lengths by 50% (1.5 car lengths) for thru traffic and 22% for left turns**
  - **Increased average network delay by 1.1 s (1.23%)**

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Key Findings from Simulation

- **During heavy traffic, increasing minimum green has negligible effect on delays and queuing because vehicle detection is already extending green beyond the minimum**
- **Within limitations of the simulation, delays <u>may</u> be less for increasing minimum green throughout the corridor, compared to increasing it at a single intersection**
- **Pedestrian signal cycles have a much larger impact on traffic delays and queuing than extending minimum green**

Choosing Minimum Green Time for Bicyclists

- **Focus mainly on bicyclist crossing times because of small effect on mainline traffic**
  - **Negligible effect observed in simulation of heavy traffic on a major arterial**
  - **When traffic is light, there are few vehicles to be delayed, those delays are short, and they are unlikely to propagate**
- **Extend minimum green throughout corridor, not just at a few intersections**
- **Seek to accommodate a high percentile of bicyclists in (green + yellow + all-red)**

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Calculating Minimum Green Time as a Function of Street Width

- ***Green time = Starting Offset time (s) + (Width in ft)/(Final crossing speed in ft/s) – (Yellow + all-red time)***

  - **T80 = 8.3 + 0.059 W (Palo Alto)**
  - **T80 = 5.3 + 0.085 W (Berkeley)**

  - **T90 = 9.3 + 0.065 W (Palo Alto)**
  - **T90 = 6.2 + 0.097 W (Berkeley)**

  - **G80 = T80 – (Y + AR)**
  - **G90 = T90 – (Y + AR)**

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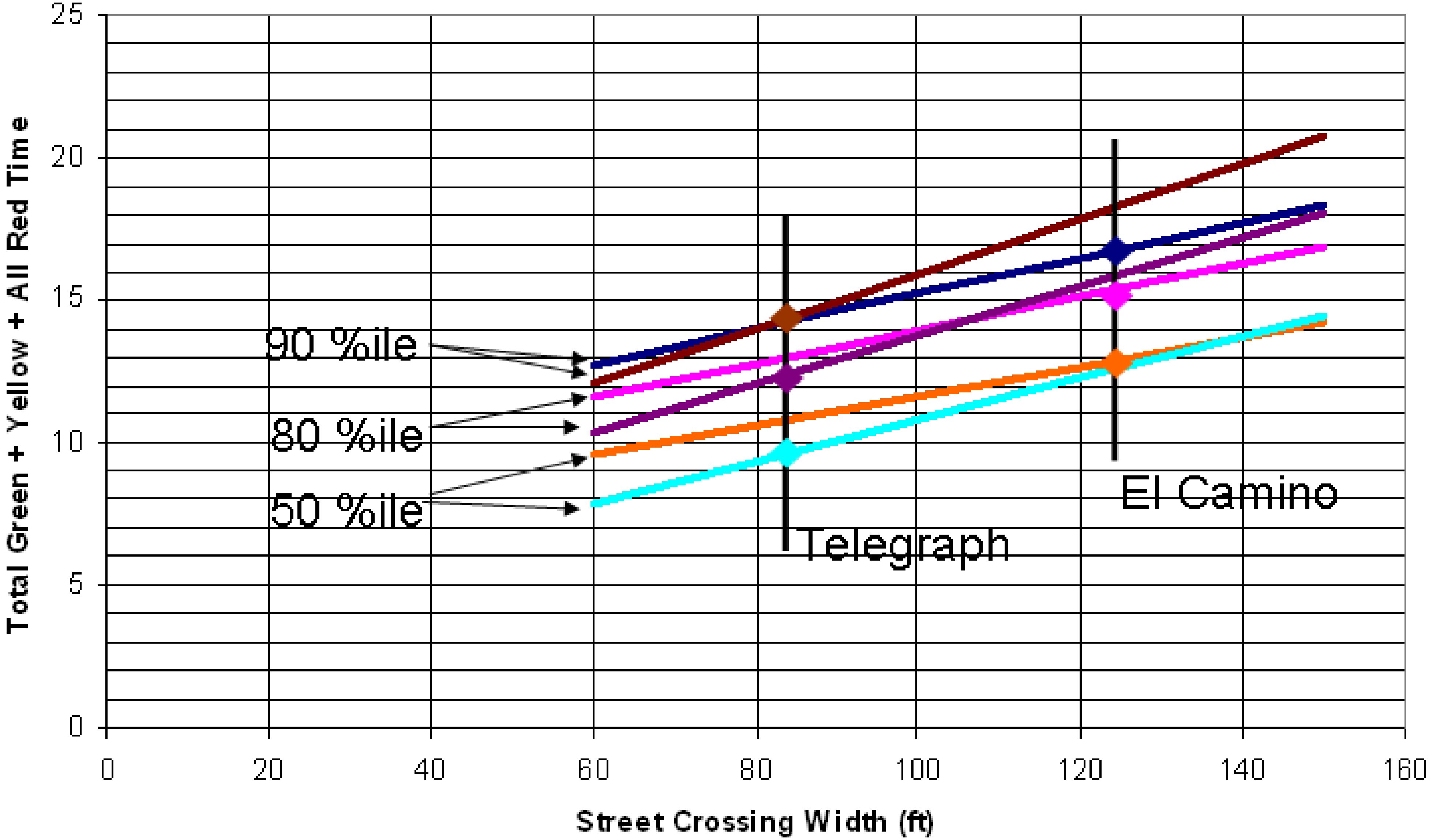
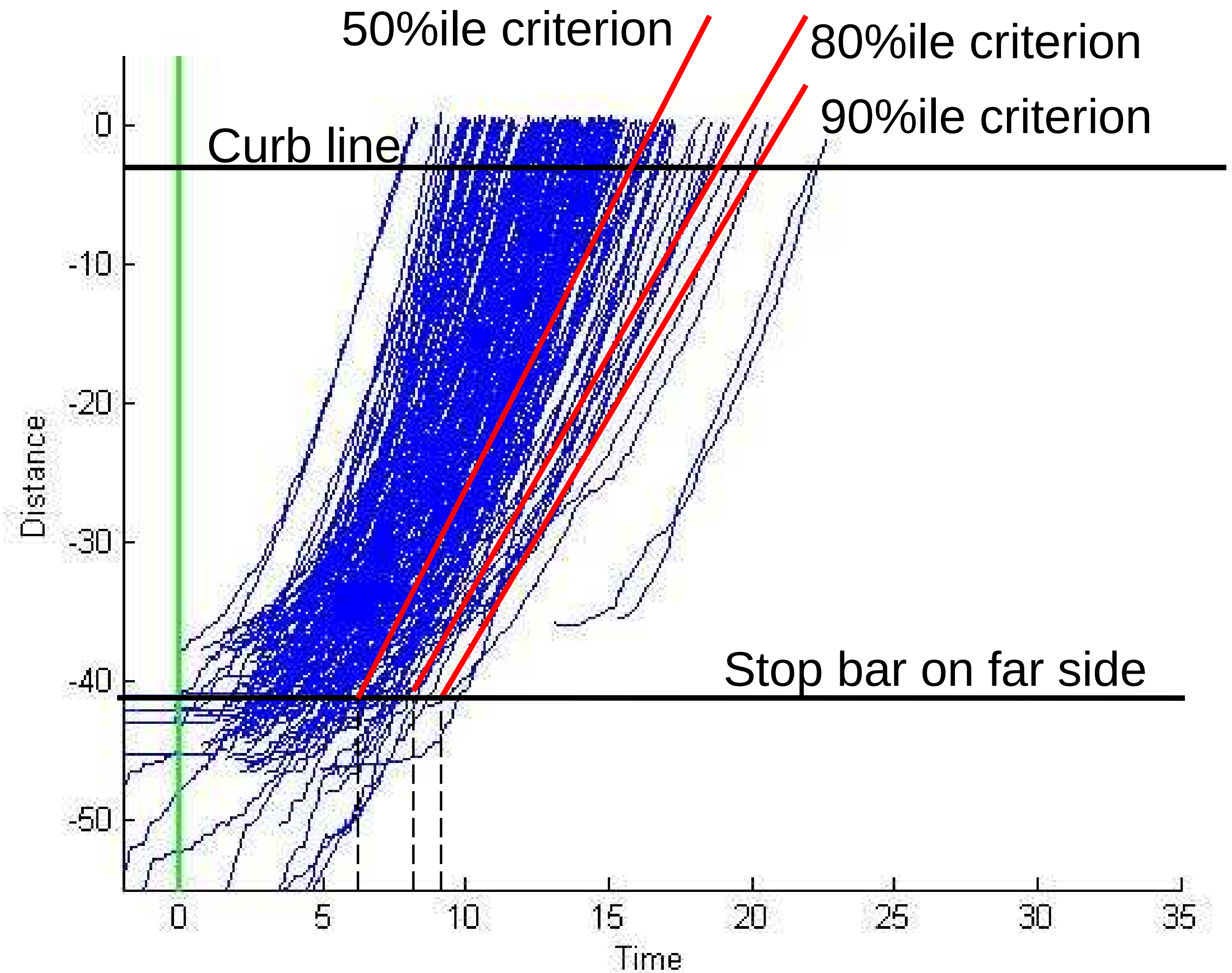
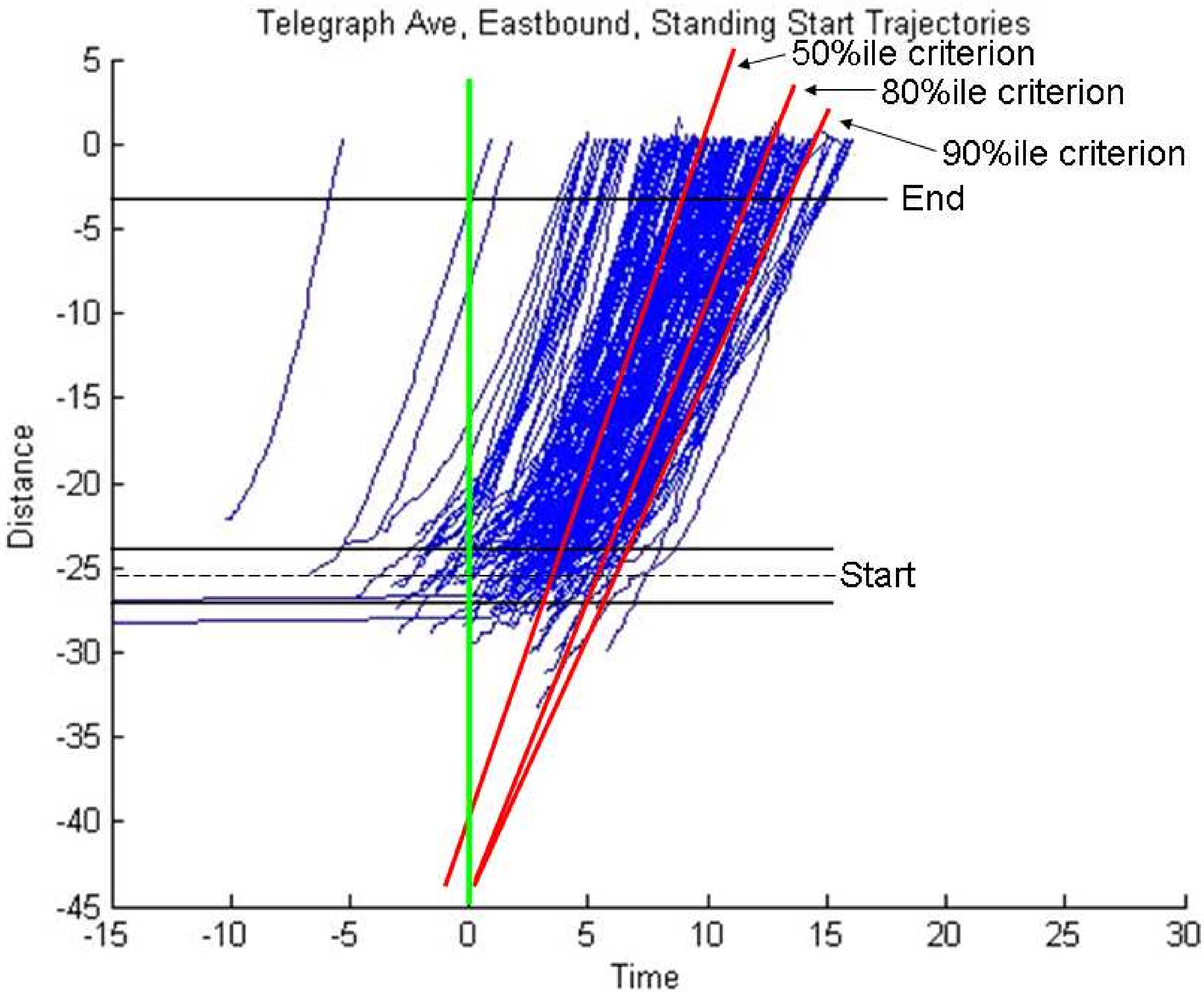
Example Values of (G + Y + AR) as Function of Street Width



Application of Potential Criteria from Park Blvd. to Park Blvd. Standing Start Data



Application of Potential Criteria from Russell St. to Eastbound Russell St. Standing Start Data



Application of Potential Criteria from Russell St. to Westbound Russell St. Standing Start Data